

General relativity and the growth of a sub-discipline “gravitation” in the German speaking physics community

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1 Introduction

During the 19th century, the topic of gravitation had been firmly embedded into the teaching of *Newtonian mechanics* although, occasionally, other theories of gravitation had also been discussed during this century (Huygens, Secchi, Lesage-Thomson, Weber-Tisserand etc) [1], [2]. Gravitational theory as a topic of research was the exception, though; only its applications played a role. Focal points were celestial mechanics and the study of the Earth’s gravitational field – in the framework of the Newtonian gravitational force. Cf. the section “Universal gravitation” of 1908 in Winkelmann’s “Handbuch der Physik” by Felix Auerbach (1856-1933) [3] who in 1921 also contributed a popularizing booklet on relativity theory [4]. It seems interesting that even in the 1960s, in an encyclopedic dictionary, a rigorous separation between the entries for gravitation/gravity (with no mention of Einstein’s theory) and general relativity was upheld [5].

Here, we will follow the growth of gravitational theory, i.e. relativistic theories of gravitation, mainly Einstein’s, as a branch of physics in the sense of social, more precisely *institutional* history.¹ Thus, the accompanying *conceptional* development is touched only as a way of loosening the narration and as help for a better understanding.² As a first step, we will ask when

¹We are aware that there is an overlap between work on *special* relativistic theories and past research in general relativity.

²Usually, physicists are more interested in the evolution of theoretical concepts and in observational progress [6].

and to what degree *general relativity* became a subject of physics research and what its relation to the “mainstream” in physics was. As criteria for a continued professionalizing of the field, we use the numbers of published research papers, reviews, monographs, courses at universities and possibly, appointments of lecturers or professors as well as the status of those involved (members of academies etc). The foundation of special institutes for gravitational research and of particular divisions of physical societies forms the final stage of this process of institutionalization. With the beginning of relativistic astrophysics in the 1960s, research work concerning general relativity also was carried through in this new field. We will try to find out whether there was a slump of research in general relativity between 1925 and 1955 in Germany. For several reasons, in the 1960s activity increased there as it also did in the United States and elsewhere. In Germany, from the 1970s to the 1990s, a continued, stable production of PhDs in the field of relativistic gravitation did occur.³

Occasionally, there is a problem of discrimination between contributions made by scientists from German speaking countries and those by scientists from other countries presented while in Germany/Austria as guest professors etc. The latter are included here because their work is taken as sign of activity in the German speaking countries. Similarly, work done at the German University in Prague (Karls-Universität), a German-language university, which existed from 1348 to 1945, will be included. Although the Netherlands do not belong to the set of countries selected, a few remarks must be made on early contributions to general relativity from there.

Obviously, any institutionalizing depends on the amount of financial means. In the first half of the 20th century, the budget of universities in the German speaking countries normally would have been able to only support a full professorship with one or at most two assistants (doctoral students or post-docs) interested in this new field. A larger group of researchers would have required third party financing. Until the 1920s, such “third parties” mainly had been the few scientific academies. In 1920, the “Notgemeinschaft der deutschen Wissenschaft” was established, a self-administrative organization combining private (industrial) and government financing. In 1929, it became renamed (Deutsche) Forschungsgemeinschaft. Einstein did obtain funds from

³The time-period of this survey will end with the beginning of the 1990s.

it for collaborators. Another funding agency, which could be and in 1924 was tapped by Albert Einstein, is the Rockefeller Foundation.

2 Before World War II: Research and teaching by single scientists

2.1 The early years of general relativity

2.1.1 Progress during World War I: 1915 to 1918

After a long maturing period, general relativity was completed in November 1915 with field equations suggested by the physicist Albert Einstein [7] and the mathematician David Hilbert [8]. (For the priority debate, cf. [9], [10], [11], [12], [13].) Unlike in the case of special relativity, the physicists around Einstein in Berlin were slow in accepting the new theory. In a letter to Arnold Sommerfeld, he expressed perfect satisfaction about his achievement, but held: “[.] but none of the peers has recognized up to now the depth and necessity of this path.” In particular, Max Planck and Max von Laue were not open to his considerations of principle [14]. Nevertheless, already in 1916 and 1917 three of the best known and most useful exact solutions of Einstein’s field equations were found. The first, describing an isolated finite spherically symmetric mass-distribution at rest, was communicated to Einstein already in December 1915 by his colleague in Berlin, the astronomer Karl Schwarzschild (1873-1916), then in Russia with the German army. The result was published in 1916 [15], [17], [16]. In the same year, a student of Hendrik Antoon Lorentz in Leiden, Johannes Droste (1886-1963), in his dissertation independently presented this same (Schwarzschild) solution [20].⁴ The aircraft-designer and professor at the Technical University in Berlin-Charlottenburg, Hans Reissner (1874-1967), followed with an exact solution for a time-independent, isolated, *electrically charged* spherically symmetric mass [21]. It was rediscovered in 1918 by Gunnar Nordström [22]. The third important solution, the de Sitter-solution, is described further below. Einstein himself propagated his new gravitational theory in an article [23] and in a book for everybody (with some physics education) [24]; in a number of papers he also worked out consequences of the theory, among others for cosmology and gravitational waves [27]. Also in 1916, the astronomer Erwin

⁴For previous work by Droste on Einstein’s theory of 1913 cf. [18], [19].

Freundlich (1885-1964) of the Potsdam observatory, who would become Einstein's paid collaborator in 1918, published a booklet on general relativity [28] to which Einstein wrote a preface backing the author:

“I have gained the impression in perusing these pages that the author has succeeded in rendering the fundamental ideas of the theory accessible to all who are to some extent conversant with the methods of reasoning of the exact sciences. (English translation of 1922 by H. L. Brose [29].)

Freundlich had been interned in 1914 in Russia, after World War I had broken out, during a solar-eclipse expedition. The physicist turned philosopher Moritz Schlick (1882-1936) who for two years fulfilled his military service at an air-base in Berlin, apparently had time to write a book, liked by Einstein, on philosophical consequences of relativity theory published in 1917 [30].

In Göttingen, the mathematicians David Hilbert and Felix Klein looked more closely into the mathematical structure of Einstein's equations and some simple solutions. Hilbert again derived the Schwarzschild metric [31], and Klein pointed to the possibility of an elliptic geometry of constant curvature in place of the spherical one. He convinced Einstein that de Sitter's solution is free of singularities, and investigated conservation laws for energy and momentum [32], [33], [34]. From the mathematical side, a most important contribution appeared in 1918: the book by the mathematician Hermann Weyl (1885-1955) [35], who in 1908 had obtained his PhD with D. Hilbert in Göttingen and at the time was professor at the ETH Zürich. Weyl also found the exact solution to Einstein's equations with cosmological constant (free of matter) corresponding to the Schwarzschild solution [36]. It was rediscovered in 1922 by the mathematician Erich Trefftz (1888-1937) [37]. Very early, in 1916, the mathematician Gustav Herglotz (1881-1953), formerly in Göttingen and then in Leipzig, also published on Riemannian geometry and Einstein's gravitational theory [40].

In Vienna, quite a few physicists and mathematician had followed Einstein's work already before its culmination in 1915 [41]. Best known among them are Friedrich Kottler (1886-1965), Hans Thirring (1888-1976), Josef Lense (1890-1985), Ludwig Flamm (1885-1964) and Erwin Schrödinger (1887-1961). Kottler had critically reacted to general relativity [42] and had received an answer by Einstein, “[..] because this colleague really has grasped

the spirit of the theory” [43]. Kottler became an unpaid lecturer in Vienna and thanked Einstein “for the benevolence toward me which you kept” [38]. In 1922, he independently re-derived the solution found by Weyl and Trefftz and concluded that Maxwell’s equations could be formulated without the use of either metric or connection [39]. Flamm introduced a pictorial representation of the Schwarzschild geometry which is used even today for picturing black holes [44]. The first approximative solution of the gravitational field for a (slowly) *rotating* solid body was given in 1918 by the astronomer, and then mathematician Josef Lense (1890-1985) and the physicist Hans Thirring [45]; the perturbation of all orbital elements were calculated. Thirring himself had worked on a rotating mass before: for a hollow rotating sphere, he derived Coriolis and centrifugal forces [46]. In July 1917, he wrote to Einstein that: “[...] the young Viennese school is occupied intensely with gravitational theory.” He hoped that Einstein would give them further advice, because since the death of Hasenöhl they were on their own [47]. (For english translations and a thorough discussion of the papers by Thirring and Thirring & Lense cf. [48].) In a brief note, Lense then published the calculated effects due to the rotation of the Earth and outer planets for some of their moons [49]. Another Viennese, Hans Bauer (1891-1953), in 1918 investigated systems of spherically symmetric fluids with a linear equation of state [50], for which the simplest solution already had been given by K. Schwarzschild. Erwin Schrödinger [51] calculated the components of Einstein’s energy-momentum complex for the external Schwarzschild metric, found that all vanish in particular coordinates, and consequently doubted its physical importance. Even more devastating was Hans Bauer’s paper showing that Minkowski space in particular coordinates led to non-vanishing components of the suggested energy density of the gravitational field [52]. In another paper, Schrödinger showed that the Einstein cosmos, found by Einstein as an exact solution of his field equations *with* cosmological constant, could be obtained from the original field equations (*without* cosmological constant) by a slight generalization of the fluid matter in the matter tensor [53].

At the time, Prague with its Karls-Universität still belonged to the Habsburg (Austrian-Hungarian) Empire. There, since 1912 until 1938, Philipp Frank (1884-1938) was succeeding Albert Einstein on his professorship. He occasionally argued against philosophers on subjects connected with special relativity [54], but is best known by his book on Einstein [55]. Until the Nazi takeover he tutored Jewish students from Germany (cf. below).

In Switzerland, apart from Hermann Weyl in Zürich, nobody followed Einstein's achievement of 1915 with serious research-work on general relativity, not even Marcel Grossmann (1878-1936) who had contributed much to the mathematical formulation of Einstein's theory [56], [57], [58]. Paul Gruner (1869-1957) of the University of Bern worked on the kinematics of special relativity; a presentation of general relativity is included only in his booklet of 1922 [59]. Einstein's former colleague at the patent office, Edouard Guillaume (1881-1959), since 1917 in correspondence pestered him with queries and own principles.⁵

Outside of the German speaking community, but in close contact with Einstein, others with an active interest in general relativity must be mentioned: the circle in Leiden around the Dutch theoretical physicist and Nobel prize-winner Hendrik A. Lorentz (1853-1928) and his colleague, mathematician and astronomer Willem de Sitter (1872-1934). In March 1917, de Sitter presented the first exact solution of Einstein's field equation *with cosmological constant*, without matter, describing the geometry of a 4-dimensional space of constant, positive curvature [61]. It was to play an important role for cosmology. From de Sitter's publications during the first world war, English scientists learned about general relativity [62], [63], [64]. For Lorentz, Droste and de Sitter see the articles by A. J. Kox [65], [66].

It is surprising that already during World War I and before its end in November 1918, such a sizeable number of contributions to general relativity could have surfaced.⁶ With the exception of H. Reissner, who had passed the of age forty, the others in Berlin and Vienna were drafted into military service; Flamm and Thirring had been dispensed, or allowed to do research valuable for the military in Austria. Schwarzschild died due to an autoimmune skin disease which broke out during his service at the front; also the Viennese physicist Max Behacker (1885-1915) who had worked on Nordström's gravitational theory was killed in action. In fact, the Nobel prize-winner Wilhelm Wien (1864-1928), "on the instigation of the supreme command of the eighth army", held lectures in the Baltic states in which he already discussed Einstein's new gravitational theory [68].

⁵As one example cf. [60].

⁶How World War I influenced physicists in Germany is described in [67].

An exceptional position was taken by a distinguished scientist remaining critical with regard to general relativity and suggesting an extended gravitational theory of his own: Gustav Mie (1868-1957), first in Halle and then, from 1924, in Freiburg/Breisgau [69], [70]. There, research in general relativity was resumed after World War II.

Outside of academia, the teacher at a Gymnasium in Wilhelmshaven, Ernst Reichenbächer (1881-1944) made a very early attempt at a unified field theory of gravitation, electromagnetism, and matter⁷ [71], [72].

Thus, in the German speaking countries, from 1915 to 1918 research on Einstein's new theory of gravitation thus was done mainly at the Prussian Academy of Sciences and at universities in Berlin, Göttingen and Vienna around Einstein, Hilbert, Klein, and Hasenöhl - also after his early death. Another germ for this kind of research formed in the neutral Netherlands at the University of Leiden around H. A. Lorentz and the mathematician Jan Arnoldus Schouten (1883-1971) in Delft [73], [74]. In the warring countries opposed to Germany, the reception of general relativity was much slower. Exact solutions of Einstein's field equations could have been derived by anyone having some knowledge about partial differential equations without need to understand the physics behind them. My impression is that, beyond those more mathematically interested physicists doing research in the field of general relativity during that time, all belonged to a small network close to Einstein, centered in Germany, and without any other "institutional structure" than the Prussian Academy of Sciences and his Kaiser-Wilhelm-Institute for Physics opened in 1917. While, on particular request by Einstein, the Academy could pay a coworker, the budget of his Physics Institute could be spent only in part for research in gravitation [75]. The activity in the field of general relativity was as constrained as that Einstein could keep track of all what went on. From his correspondence we learn that he knew about everyone working on his gravitational theory; he reacted defensively to pub-

⁷Reichenbächer studied mathematics and in 1903 received his doctorate from the University of Halle. At first, he did not enter an academic career, but started teaching at a Gymnasium in Wilhelmshaven at the North Sea, then in Königsberg on the Baltic Sea. In 1929 he became a Privatdozent (lecturer) at the University of Königsberg (now Kaliningrad, Russia). His courses covered special and general relativity, the physics of fixed stars and galaxies with a touch on cosmology, and quantum mechanics. In the fifth year of World War II he finally received the title of professor at the University Königsberg, but in the same year was killed during a bombing raid on the city.

lications pointing out some weakness in his formalism, cf. [76], [77].

Einstein had also close ties with the editor of the scientific magazine “Die Naturwissenschaften” built after the corresponding English journal “Nature”, Arnold Berliner (1862-1942), who used to ask him for his advice (cf. [78]).

2.2 The media hype: 1920-1924

The announcement in 1919, by two British solar-eclipse-expeditions on the verification of Einstein’s prediction concerning the light deflection by the Sun, set off an avalanche of public reactions in Germany. One of them was the unprecedented scientific glorification of Albert Einstein, the new Archimedes, Kopernikus, and Newton in one. Another, the flood of publications, both pro and con general relativity, in the form of popular brochures and serious books. Its volume and distribution over the years may be taken from my article of 1992 [79]. As discussed there, a correlation with the financial and economical situation in Germany is likely. There are indications that Einstein was more than willing to encourage those who were spreading the word about his theories. An example for this is given by Moszkowski’s book “[...] on relativity theory and a new system of the world modeled from conversations with Einstein” ([80], subtitle).

We will mention just a few examples for both scientific and popular publications during this period. After his successful monograph on special relativity [81], Max v. Laue wrote a second part “On general relativity and Einstein’s teachings on gravity” [82]. Unlike v. Laue’s rather technical book, Hans Thirring published one without any formula: with the explicit aim “to uncover the relations among the basic ideas of relativity theory” [83]. Likewise, Max Born wrote an “easy-to-understand” book on relativity theory, not as heavy as v. Laue’s, but still with many formulas [84]. It was successful; in its third edition, Born omitted the picture of Einstein on the frontispiece “[...] in order to avoid the appearance that personal sympathy mixes with my scientific convictions [...]” ([86], p. IX). Wilhelm Wien, in a lecture of March 1921 given at Siemens & Halske in Berlin, tried to describe both special and general relativity “sine ira et studio”. He accepted only three objections toward the theory: Contradictions within the mathematical structure, consequences which are not in agreement with experiment/observation, or unsuitability of the theory for a final representation of natural processes due

to an abandonment of simple principles [85].⁸

As to brochures and booklets for the general public, Einstein apparently was aware of quite a number of them. He had read the manuscript of a text by his previous student in Berlin, Werner Bloch (1890-1973), probably his book of 1918 [87], which had reached its 3rd edition in 1921. He told him:

“With interest, I read through your introductory work on relativity theory and convinced myself that your statements are thorough, easily comprehensible and well arranged” [88].

In a recommendation by him four years later, the text was described as “a good booklet for an introduction into relativity theory” [89]. Einstein also knew Pflüger’s brochure [90], “a not badly written popularizing text about relativity” [91]. Other authors just sent their writings to Einstein, like Harry Schmidt (1894-1951) from Hamburg whose booklet reached several German editions and was translated into English and Italian [92], [93]. Einstein’s adversaries blamed him for his explicit support for an author of a popularizing brochure who claimed in his preface that he was no longer able to prove “a modest theorem of Euclidean mathematics by hand” [94].

Well before this overwhelming public interest in Einstein’s theories, lecture courses on general relativity had sprung up at various universities in the German speaking countries: Already in 1918 L. Flamm lectured at the University in Vienna, while Ludwig Hopf in Aachen and W. Matthies in Basel⁹ gave their courses during the winter term 1918/19. In Berlin, Einstein followed in the summer term of 1919. Some of the courses were then expanded into books: In Heidelberg, the astronomer August Kopf (1882-1960) regularly lectured about relativity theory from the winter term 1919/20 until 1923 [95]. In Marburg, the mathematician Ernst Richard Neumann (1875-1955) followed suit in 1920/21 [97] whereas one year later, in the winter

⁸“Wirkliche Einwände gegen die Relativitätstheorie können daher nur von dreierlei Art sein. Entweder man muß innerhalb des mathematischen Systems der Theorie Widersprüche aufdecken. Oder man muß zeigen, daß sie zu Folgerungen führt, die mit der Erfahrung nicht übereinstimmen oder schließlich muß man den Nachweis führen, daß sie sich wegen der Preisgabe einfacher Grundsätze zur endgültigen Darstellung der Naturvorgänge nicht eignet”.

⁹In 1920, Matthies became Dean of the Philosophische Fakultät (with its Mathematisch-naturwissenschaftliche Abteilung) of the University of Basel.

term 1921/22, Wilhelm Lenz, then at the University of Rostock, lectured on “Relativity Theory II (general)” [96]. A former teacher and insurance mathematician Paul Riebesell (1883-1950) even prepared a booklet on relativity theory as an assistance for the teaching in college or high school [98].

Besides Moritz Schlick, other philosophers also had discovered the field. Most of them were in direct contact with Einstein and supported by him: His former student Hans Reichenbach (1891-1953) [99] asked for Einstein’s permission to dedicate his book to him; eventually, he became sort of a philosophical “watchdog” for Einstein; for Schlick and Reichenbach cf. [100]. Ernst Cassirer (1874-1945) [101] sent Einstein his manuscript who read and praised it. Ilse (Rosenthal)-Schneider (1891-1990) [102] wrote her dissertation in Berlin and corresponded with Einstein as did also Joseph Petzold (1862-1929) [103]. For Einstein’s relation to Kantian philosophy, as represented by Ewald Sellien (1893- ?) [104] and Alfred C(oppel) Elsbach (1897-1932) [105] among others, see the article by K. Hentschel [106]. Sellien, who later became a teacher at a Gymnasium, had dedicated a copy of his dissertation to Einstein “in high respect and reverence”, but the respected did not like his work and wrote to Schlick: “Did you see the quite silly dissertation by Sellien (student of Riehl)?” [107].

Besides these full time philosophers, philosophically inclined scholars with an interest in physics also published on general relativity. An example is Franz Selety (Jeiteles) (1893-?) in Vienna who corresponded with Einstein and criticized his cosmological ideas. Instead, he proposed a hierarchically arranged cosmological model within Newtonian gravitational theory [108] which was not accepted by Einstein (cf. [109] and the response by Selety [110]). After further papers, Selety disappeared in Paris without leaving a trace, scientific or otherwise.¹⁰ [112].

A scientific highlight in the first half of the 1920s coming from *outside* the German speaking physics community was the presentation of time-dependent homogeneous and isotropic exact solutions of Einsteins field equations with cosmological constant in *Zeitschrift für Physik* by the physicist and mathematician A. Friedmann of St. Petersburg [115], [116]. These solutions contradicted Einstein’s philosophical beliefs pointing to a statical universe; it

¹⁰Cf. the biographical sketch by H. Kragh [111].

took some effort until he accepted them [117], [118].

2.3 The Einstein Tower

A project instigated by Freundlich and backed by Einstein was the building of a telescope for the investigation of the solar spectrum with high precision. Its main purpose was to measure the redshift of the solar lines predicted by general relativity. The architect Erich Mendelsohn (1887-1953) suggested an expressionistic building in the form of a tower on a lengthy foundation. The telescopes inside the tower directed the light to the measurement area in the basement. Measurements finally could start in 1925, but did not (and could not) agree with the predicted solar redshift until after the 1950s [119]. Although the observatory in the Einstein-Tower did very important work for the solar spectrum and other topics in astrophysics, it failed completely on its intended purpose. The building of the Einstein Tower can be interpreted as an attempt to institutionalize general relativity within observational astronomy, which at the time was very reluctant to include Einstein's theory in its agenda. A successful embedding occurred only 40 years with the newly introduced field of relativistic astrophysics

2.4 Opposition against relativity theory

Another aspect must be taken into account: the reception of general relativity in the German physics community was not unanimous. It was criticized by a few influential experimental physicists like the Nobel prize winners Philipp Lenard (1862-1947) [120], [121] and Johannes Stark (1874-1957) [122], and by Ernst Gehrcke (1878-1960), a specialist in optics at the Physikalisch-Technische Reichsanstalt¹¹ in Berlin [123]. At first, in particular Lenard's criticism followed physical arguments which Einstein tried to refute. However, Lenard's attitude then transformed into pure resistance, colored by nationalism, and later anti-semitism. Criticism was voiced also by philosophers like Hugo Dingler (1881-1954) [124]. The arguments presented never succeeded to convince the great majority of those working on general relativity. Nevertheless, they might have discouraged young scientists to enter the field.

¹¹The German national Metrology Institute.

2.5 The second half of the twenties

After World War I, German researchers had been excluded from international conferences until 1926, when Germany became a member of the League of Nations [125]. The boycott had weakened since 1922 and was practically over in 1925. Einstein worked strongly for an end of it.

With the advent of quantum mechanic in 1925 to 1926, unlike with that of general relativity, no comparable hustle and bustle went on in the press about the new theories of Heisenberg, Born, Jordan, Schrödinger, and Dirac. Although the public attention to general relativity dwindled in significance, money still could be made by writing a book on relativity. In his early report on the theory of relativity of 1920, Wolfgang Pauli (1900-1958) had included general relativity as a single chapter [126]. With basic knowledge about general relativity available in the meantime, it could be summed up now by its own in encyclopedias and textbooks. Such were the contribution by August Kopf to the volume “Physics of the Cosmos” of the widely used Müller-Pouillet textbook of physics [127], or two separate entries in the Geiger-Scheel “Handbook of Physics” by Hans Thirring and his former doctoral student Guido Beck (1903-1988) [128]. Thirring also gave a review of relativity theory in a newly founded scientific journal [129].

2.5.1 How Einstein supported his coworkers financially

From the 1920s on, Einstein had several coworkers in Berlin: Jakob Grommer (1917-1931), Cornel Lanczos (1928-1929)¹², Hermann Müntz (1928-1929), and Walther Mayer (1931-1933). In 1921, Grommer received some money from Einstein’s Kaiser-Wilhelm-Institute for Physics; in 1924 Einstein obtained a fund of 1000 \$ from the Rockefeller Foundation. Perhaps this money was going to Grommer; it is unknown to me who contributed his regular salary, if he had one. Lanczos had a research fellowship from the “Notgemeinschaft der deutschen Wissenschaft”. Mayer was payed by the Academy of Sciences [131]. Müntz did not need money from Einstein: Since 1924, he

¹²Lanczos had discovered a simple axially symmetric solution of Einstein’s field equations [130].

was teaching mathematics at a Gymnasium in Berlin.¹³

2.5.2 Einstein's role in the appointment of professors

Einstein's fame brought him many requests for his advice in matters of professorial appointments at universities. Already before he became famed, he had effectively suggested Philipp Frank as his successor in Prague. From Vienna he was asked about the filling of the chair the physicist Franz S. Exner (1849-1926) would leave, in particular whether he could recommend Felix Ehrenhaft (1879-1952) [133]. In Zürich, a decision among four colleagues had to be made; he voted for Simon Ratnovsky (1884-1945) [134]. In Leipzig, a theoretical chemist was searched for the appointment as extraordinary professor [135]. David Hilbert in Göttingen wrote Einstein for his opinion on Max Born as possible (and then the actual) successor of Peter Debye [136]. For the university of Tübingen, he suggested, as possible successors of the famous spectroscopist Friedrich Paschen (1865-1947), James Frank and Edgar Meyer [137]. Walther Mayer (1887-1948) whom Einstein had helped to gain an unpaid position as lecturer at the University of Vienna, became his assistant in Berlin in 1929. In spite of his growing influence in such matters, except for Lanczos I, know of no one who obtained a professorship in the German speaking countries due to his research in general relativity.¹⁴ At the time, general relativity just was not deemed to have such an importance as to be accepted as a noteworthy separate branch of physics.

2.5.3 Further work on general relativity

It seems that, world wide, there was only a minor slump in scientific publication on general relativity from the second half of the 1920s until 1945. An inspection of the bibliographies by Combridge at King's college [138] and in Synge's book on general relativity [139] shows no remarkable change in the source-volume referring to the period between 1915 and 1960. What happened was that the focus of research on general relativity shifted from Germany to other countries. After 1927, Einstein published on the problem of motion with his assistant Jakob Grommer (1879-1933) [140], [141].

¹³For a brief biographical entry on Müntz, see my first article on the history of unified field theories [132].

¹⁴In fact, Lanczos never filled his position as extraordinary professor in Frankfurt obtained in 1932; he remained in the United States.

In 1931, he applied for and obtained funds from the Rockefeller Foundation for a visit of Myron Mathisson (1897-1940) from Cracow to Berlin who had made progress in the study of equations of motion of pole-dipole particles.¹⁵ Since 1925, Einstein more and more published on generalizations of his theory to five-dimensional or non-riemannian spaces; others like Cornel Lanczos in Frankfurt continued with research in general relativity [144], [145].¹⁶

Erwin Freundlich pursued his work for the empirical support of general relativity. In 1929, with astronomers H. von Klüber and A. von Brunn from the Potsdam Observatory, he undertook a solar-eclipse-expedition to Sumatra. For the light-deflection at the brim of the sun they found a higher value than that predicted by Einstein's theory [147].

In Vienna, Flamm, Kottler and Thirring no longer did research work on gravitation; Hans Bauer [148] and Guido Beck still contributed [149] as well as Paul Lazarsfeld (1901-1976) with a doctoral thesis [150]. Lazarsfeld later turned to social research; he is called the “founder of modern empirical sociology.” Hans Bauer earned his living as a teacher at a Gymnasium. Kottler wrote two historical papers on relativity [152], [153] but then went into optics [151]. Schrödinger had been called to Zürich in 1920, where he found his wave equation, and then to Berlin in 1927.

The end of the 1920s reflects a discrepancy between the level of awareness about Einsteins relativity theories among the general public in Germany, and the rather restricted professional possibilities for doing research on Einstein's theory of gravitation. We note that the majority of those standing out for their contributions to general relativity – Einstein, von Laue, Pauli and the mathematician Weyl included – had won or earned their reputation in fields of physics unrelated to gravitation. The possibility for obtaining a full-time job within the field of general relativity just did not exist. According to the majority-opinion, general relativity with its prediction of only three observable effects in urgency had fallen way behind the new quantum physics with its many applications. We can only guess what would have happened if quantum mechanics had **not** come into being, but it seems safe to say that

¹⁵Tilman Sauer has given a precise chronology of the application to the Rockefeller Foundation [142]. In the end, the visit of M. did not materialize. For some facts about Mathisson's life, see [143].

¹⁶For Lanczos' early contributions to general relativity cf. [146], pp. 449-518.

research on general relativity would not have augmented dramatically.

2.6 Research until and during World War II

2.6.1 The thirties

During the 1920s and 1930s, due to new powerful telescopes in the United States the hope grew that something about the large scale distribution of matter in the cosmos could be found out. In the context of Friedmann's solutions, independently found by the Belgian priest and astronomer, Georges Lemaître (1894-1966) [154], [155], [155], a noteworthy development started: Einstein finally accepted the "expanding" solutions and, with Willem de Sitter, created the Einstein-de Sitter cosmological model [157]; cf. also [158]. Before him, the astronomer Otto Heckmann (1901-1983) at the observatory in Göttingen had independently published detailed investigations of Friedmann's solutions [159], [160]. De Sitter who had received a copy of Heckmann's publication mentioned Heckmann's name in his joint paper with Einstein without giving a precise reference.

A different contribution came from the American mathematician Oswald Veblen (1880-1960) who in 1932, as a guest professor, lectured on projective relativity in Göttingen, Hamburg and Vienna. The lectures were published as a book [in German language] in the following year [161]. This research-topic found its continuation in Germany after World War II in Hamburg and Berlin (cf. section 3.1).

Einstein's interest had shifted to his attempt at using geometries more general than Riemann's for building a field theory unifying the gravitational and electromagnetic interaction and, if possible, including even further particles. While in 1931 he formally supported the application to the Rockefeller Foundation for funds allowing the construction of an as yet not existing building for the Kaiser-Wilhelm-Institut für Physik, Max von Laue and others in the committee were the real promoters. Gravitation does not seem to have been envisaged as one of the main topics to be studied in the building.

2.6.2 The impact of the Nazi rule

When the National Socialists had gained power over Germany in 1933, the number of scientists involved in general relativity decreased considerably. Einstein and his Jewish assistant for calculations, Walther Mayer, emigrated to Princeton. Einstein's former assistant in 1928/29, Cornel Lanczos, since 1931 as a guest professor at Purdue University in Indiana, USA, did not return to Germany.¹⁷ F. Kottler and H. Reissner due to their Jewish ancestors also had to leave the country.¹⁸ In 1933, Felix Auerbach in Jena committed suicide together with his wife. Hans Thirring was forced into retirement in 1938 after the German occupation of Austria. This also happened to Schrödinger at the university in Graz who regularly lectured in Vienna (cf. [41] p. 190-192). Thus, no further research on general relativity was done in Vienna until after World War II. In Berlin, the situation was not much better: Max von Laue, although in opposition to Nazi ideology, stayed on. His assistant of 1933 to 1940, Max Kohler (1911-1982), wrote a dissertation "Contributions to the cosmological problem and the propagation of light in gravitational fields" [163] but afterwards switched to crystal symmetries and electron theory of metals ("Kohler's rule" for magnetoresistance). After a professorship in Greifswald, obtained in 1943, and meteorological service during part of the war, in the 1950s he again published on relativity theories. Max Born left Göttingen in summer 1933. He was known as co-founder of the new quantum mechanics and had done only pedagogical work in general relativity. Nevertheless, he was a good friend of Einstein and certainly sympathetic to research in relativity theory. Among the philosophers, already in 1933 Hans Reichenbach in Berlin had lost his position; likewise Ernst Cassirer in Hamburg. The climate for research on Einstein's relativity theories became forbidding. The student from Freiburg/Breisgau, Peter Bergmann (1915-2002), later to become an assistant of Einstein in Princeton, in 1936 wrote his PhD-thesis with Philipp Frank in Prague at the German University Prag on "the harmonic oscillators in spherical space" [164].

¹⁷As Einstein stated explicitly that, during all of his life, he occupied only Jewish assistants.

¹⁸Kottler earned his living in the optical industry in the USA while Reissner became associated first with the Illinois Institute of Technology and then with the Polytechnical Institute of Brooklyn [162]. I owe this reference to F. W. Hehl, Cologne.

Nevertheless, some isolated research went on in Germany.¹⁹ In 1938, M. v. Laue reacted to a paper by H. P. Robertson on the apparent luminosity of a receding nebula with an impact to cosmological theory [166]. In 1939, at the Physics Institute of the Technische Hochschule Stuttgart, Helmut Hönl and A. Papapetrou came back to the solution of Einstein's field equations for a massive charged point particle and investigated it from the point of view of self-energy [167]. Papapetrou continued by looking at the gravitational field between pole-dipole particles [168]. In 1942, Otto Heckmann published his book on cosmology, which contained a presentation of Einstein's gravitational theory [169]. Also, a few books on the "worldview" of the sciences like the book by E. Schneider [170] or the translation of Eddington's [171] and Hubble's [172] books continued to discuss Einstein's relativity theories and cosmology.

But what really happened after 1933, was a definite *shift of research to the United States*. Einstein's move to Princeton was not the main reason, although he still contributed to general relativity, e.g., by his work with L. Infeld and B. Hoffmann on the equations of motion of point particles [173], and with W. Pauli on the non-existence of regular stationary exact solutions of his field equations [174], [175]. Most important was work on gravitational collapse leading to the TOV (Tolman, Oppenheimer Volkoff) - limit for the mass of neutron stars [176].

The adversaries of Einstein's relativity theories in Germany, mentioned above, now presented themselves as outright anti-Semites battling what they named Jewish thinking.²⁰ According to them, quantum mechanics was also included in such thinking. They succeeded to fill a couple of full professorships with Nazi sympathizers, in particular Sommerfeld's chair in Munich, and the chair for astronomy in Vienna. There, Bruno Thüring (1905-1989) became director of the observatory and had the time to do "research" on "the Jewish question" [179]. After he had been fired in 1945, he tried to hide his antisemitism behind the philosophy of Hugo Dingler. Dingler in public had attacked Hans Reichenbach as "Einstein's favorite philosophical associate"; cf. the article by G. Wolters [180]. In a booklet, in 1985 Thüring

¹⁹This invalidates the opinion in [165], where it is claimed that research on general relativity had completely vanished after 1933.

²⁰Since 1925, Lenard, in an attempt to influence the German Physical Society, had already criticized "the Berlin Jews" in his correspondence [178].

suggested a cosmological model without expansion and big bang – without ever mentioning Einstein, de Sitter or Heckmann [181].

2.6.3 The war years

After a moratorium reached in 1942 between those most fervent against quantum mechanics and relativity theory and those who wanted to keep physics research free of influence from Nazi organizations (“Seefelder Religionsgespräche”), the teaching of quantum mechanics and of general relativity no longer was obstructed [182]. An example is given by the call of C. F. v. Weizsäcker who worked on cosmogony to the Reichsuniversität Straßburg in 1942 [183]. Wilhelm Lenz at the University of Hamburg could give courses on “(Special) Relativity Theory” both in summer 1943 and 1944 [184]. Already in 1940, in the 2nd trimester, Hermann Dießelhorst at Technische Hochschule Braunschweig had lectured on “Fundamental structures of relativity theory” [185]. A certain amount of publication of books dealing with Einstein’s relativity theories continued. They mostly contained discussions of a more general nature (natural philosophy) like in the books by Heisenberg [186], Jordan [187] and Bernhard Bavink (1879-1947) [188], or by the theologian Arthur Neuberger (1866-1961) [189]. But there was also a textbook on electrodynamics by Mie including relativity [190], and the one on cosmology by Heckmann mentioned before [169]. Nevertheless, toward 1945 due to the war efforts and destructions in Germany, serious research on general relativity had gone into hibernation.

In democratic Switzerland, courses on special and general relativity were never considered taboo. In 1940, André Mercier in Bern lectured on “General relativity theory and tensor calculus”, and Wolfgang Pauli on “Relativity and gravitational theory for advanced students”.

3 After World War II: Research groups and interactions

With thirty years passed since the completion of general relativity, Einstein’s theory had to face a rival: Kaluza-Klein theory. Moreover, Pascual Jordan

had started to develop scalar-tensor theory²¹ as an alternative gravitational theory. He did not know that the Swiss mathematician Willy Scherrer (1894-1979) of Bern, in 1941 had suggested the same theory in another context [191].²² Einstein was fully absorbed by his many attempts at a unified field theory. Nevertheless, the years following Einstein's death in 1955 brought the acceptance of general relativity in the German speaking countries as the only gravitational theory accepted by the majority of those involved in gravitational research.

After its defeat and division into occupied zones, Germany and Austria were in dire straits. While universities opened rather quickly, the Deutsche Forschungsgemeinschaft reconstituted only in 1949 and since 1951 functioned well, more or less. Einstein's Kaiser-Wilhelm-Institute for Physics under the vice-director Max von Laue (1922-1933) and directors Peter Debye (1935-1940) and Werner Heisenberg (1942-1945) had phased out gravitational research. In 1946, the institute reopened in Göttingen under Heisenberg and engaged in nuclear physics, quantum field theory and elementary particles. In summer of 1947, a new department for astrophysics, directed by Ludwig Biermann (1907-1986) became added. Thus, until the early 1950s, support for research on general relativity proper again could come only from single university professors.

3.1 Federal Republic of Germany (BRD)

3.1.1 From 1945 to the end of the 1950s

Since 1944, Pascual Jordan (1902-1980) had been full professor at the University of Berlin; after 1945 he no longer could claim his position when this university was reopened in the Soviet Sector of Berlin. He had to wait until, after his denazification in 1947, he obtained a guest-professorship at the university of Hamburg with the help of a recommendation by Wolfgang Pauli. He pondered on Dirac's large number hypothesis and on a theory of gravitation with an additional scalar field replacing the gravitational constant in Einstein's theory. This theory could be embedded into projective relativity. Another one publishing in this field was Günther Ludwig (1918-2007)

²¹Due to the destructions toward the end of World War II, Jordan's first paper on the subject, submitted to *Zeitschrift für Physik* **46** in 1944, had not appeared.

²²Cf. my paper on the genesis of scalar-tensor theories [192].

at the Free University Berlin, founded in June 1948 in the Western Sectors, and his collaborators Claus Müller [193] and Kurt Just. From 1954 to 1956, K. Just published eleven papers plus one with G. Ludwig [194] on Jordan's gravitational theory.

In 1952, in his book "Gravitation and Cosmos" [202], Jordan gave a summary of the results he and Heckmann's collaborators had reached. Since 1942, Otto Heckmann had been director of the Hamburg observatory in Bergedorf.²³ He worked also on what later would be named scalar-tensor theory and on its consequences for cosmology. Heckmann had the advantage of being firmly established and with positions to be filled by collaborators like the astronomer Walter Fricke (1915-1988), later director of the Astronomisches Rechen-Institut, Heidelberg. Engelbert Schücking (1926-2015) who in 1952 had become a student of Jordan, received his PhD in 1956 on non-static spherically symmetric solutions of Jordan's vacuum field equations. He eventually became his assistant. Together, they obtained exact solutions of Newtonian cosmology analogous to the Gödel metric in general relativity [196], [197]. With Schücking, Heckmann also wrote two articles on cosmological theory (Einstein's and alternative theories) in the new Encyclopedia of Physics (1959) [198], [199]. Schücking tutored Istvan Ozsvath (1928-2013) from Hungary who obtained his PhD with Heckmann in 1960. Ozsvath also published with P. Jordan [200], [201]. In 1963, he left Hamburg for Texas where he became full professor in 1967 at the University of Texas at Dallas.

In 1953-1954, after Jordan had become full professor, his seminar on relativity and gravitation started to cooperate with Heckmann. At the time, he also continued his long-standing interest in pure mathematics and worked on skew lattices (special kind of algebras) [203], [204]. New students came in with Jürgen Ehlers (1929-2008) becoming the most prominent, and Wolfgang Kundt (1930-). Their scientific contributions are already mentioned in the improved second edition of Jordan's book which appeared in 1955 [202]. Nevertheless, in 1955 only J. Ehlers could accompany P. Jordan to the Jubilee Conference in Bern; although O. Heckmann lectured there on a paper with E. Schücking, the latter was not present at the conference. G. Ludwig talked about a paper with his coworker K. Just. In 1958, both Ehlers and Kundt obtained their doctoral degrees with Jordan. Due to his reputation, it was not difficult for Jordan to renew international contacts. Rainer Sachs, who obtained his Ph.D. at Syracuse University, N.Y. with Pe-

²³Cf. my entry for Otto Heckmann in the Dictionary for Scientific Biography [195].

ter Bergmann, joined the Hamburg group as a postdoc in late 1958, just before Kundt went to Syracuse in January 1959. Kundt returned to Hamburg in the spring of 1960, when Sachs returned to the States. In 1960/1961, Dieter Brill (1933-) from Princeton University also visited Jordan's group in Hamburg as a post-doctoral fellow. Further guests at the group's colloquium included well-known Wolfgang Pauli, Peter Bergmann himself, and his former student Joshua Goldberg who, from 1956 to 1963, was responsible for the United States Air Force support of research in general relativity. In 1961, E. Schücking went to P. Bergmann on a fellowship and established further contacts with astronomers and astrophysicists. The influential Alfred Schild (1921-1977), since 1957 at the University of Texas at Austin, in 1962 procured an associate professorship for E. Schücking in the mathematics department. From then on, Schücking was continuing his research outside the German relativity community.

After the move to Munich in 1958, the Max-Planck Institute for Physics with its two departments under W. Heisenberg and L. Biermann, was renamed Max-Planck Institute for Physics and Astrophysics. In the 1970s and 1980s, research on general relativity (J. Ehlers) and cosmology (G. Börner) became included in the agenda of the department for Astrophysics.

3.1.2 From the 1960s to the 1980s

Another early member of the group since 1957 was Manfred Trümper²⁴ who joined the seminar in 1957 and obtained his PhD with Jordan in 1962 [205], [206]. Already in 1958, J. Ehlers and K. Kundt showed, by their doctoral theses, that the emphasis in the group's work had shifted to mathematical aspects of general relativity, including the search for exact solutions.²⁵ Coordinate-free covariant methods were developed and applied to the definition of radiation and the description of fluid matter. The results were published from 1960 to 1965 in the proceedings of the Academy of Sciences and Literature in Mainz.²⁶ Jordan still worked out consequences from Dirac's large numbers hypothesis for geophysics: the Earth should have expanded during its past [211]; in addition to the previous acknowledgments, now Man-

²⁴He is a younger brother of the well-known astrophysicist Joachim E. Trümper.

²⁵J. Ehlers wrote his dissertation on "Construction and Characterization of the Einstein equations."

²⁶Some of them were translated into English and reprinted as "Golden Oldies" in the journal of General Relativity and Gravitation [207][208], [209], [210].

fred Trümper is also in the list of contributors. He had become post-doc with Peter G. Bergmann at Syracuse University in the academic year 1962/63, and in 1963/64 at Yeshiva University in New York. In the years 1965 to 1969, he was assistant to P. Jordan.

Thus, the ties between Peter G. Bergmann and Pascual Jordan with regard to the exchange of post-doctoral fellows were already tight when Jordan visited the US (New York) in 1963. Due to these frequent exchanges between some of the members the Hamburg group and young colleagues of the United States, Jordan was forced to raise a considerable amount of money. A big spender was Friedrich Flick (1883-1972), one of the richest men in the BRD with an ugly Nazi past. Other sources were the Volkswagen Foundation, the Fritz ter Meer Foundation, or the Academy of Science in Mainz. The contracts with the European Office of the Aerospace Research USAF between 1958 and 1967 were very important. In 1964, Jordan and four of his young collaborators wrote a (third) final report of more than 100 pages “Contributions to Actual Problems of General Relativity” for this monetary source. He also needed some time for his role as a member of Parliament in the Bundestag in Bonn from 1957 to 1961. One may safely assume that most of the research work in gravitation was actually achieved by his younger collaborators who welcomed his name for making themselves known. At least until the end of the 1960s, the Hamburg group was the largest and most influential of the groups in Germany working on general relativity. In 1966, P. Jordan proudly stated about his Hamburg seminar:

“The development of this seminar was able to contribute to the accomplishment of the task of keeping alive the German participation in research on relativistic gravitational theory. There was a danger in this respect, because in the preceding period relativity theory had stood back greatly in the awareness of German physicists. When the new beginning started, nuclear physics and elementary particles were outshining relativity.”²⁷

²⁷Die Entwicklung dieses Seminars konnte einen Beitrag leisten zur Lösung der Aufgabe, in der Bundesrepublik die deutsche Mitarbeit an der relativistischen Schwerkraftforschung nicht einschlafen zu lassen. Gefahr in dieser Richtung war gegeben, da in der vorangegangenen Zeit die Relativitätstheorie im Bewusstsein der deutschen Physiker stark zurückgetreten und beim Neuanfang zunächst von Kernphysik und Elementarteilchen gewissermaßen überstrahlt war.

3.1.3 The first step toward institutionalization of gravitation research

A step toward the institutionalization of gravitational research in West-Germany was made only at the beginning of the 1970s, roughly simultaneously with the foundation of the International Society on General Relativity and Gravitation in Copenhagen in 1971. The Hamburg Seminar faded after P. Jordan had retired and the Hamburg faculty did not replace him by a colleague who would continue research in gravitation. With Lehmann and Döring on the faculty, research and teaching in the field of gravitation was deemed unnecessary.²⁸ Whether the disdain of the faculty for the topic of gravitation, or unease about Ehler's monopolizing personality were decisive, remains open. As one of the most active members of the group, J. Ehlers, from 1964 until 1971 mostly worked in the United States, first from 1964 to 1965 at the University of Texas in Dallas and then from 1966-1971 at the University of Texas in Austin.

Also W. Kundt had been attracted to the US: as a Flick exchange fellow he went to Syracuse in January 1959 where Rainer Sachs was to receive his PhD; Sachs then joined the Hamburg group for a year. Kundt returned to Hamburg in the spring of 1960, when Sachs returned to the United States. Since 1971, he had become titular professor in Hamburg. Jordan's PhD-student H.-J. Seifert was tutored by him (1969).²⁹ Yet, from 1972 on he changed the field of research and went into astrophysics in Bonn. Nevertheless, until 1975 he tutored students in Hamburg, applied and received support for them by Deutsche Forschungsgemeinschaft. From 1968 to 1969, M. Trümper was drawn to the University of North Texas in Denton, north of Dallas, and from 1969 to 1974 to Texas A&M University in College Station. After some time at the Max-Planck-Institute for Astrophysics in Ehler's department (see below), he worked in several countries on three continents. At the time, after World War II, even a little known place in academia, in particular for gravitational theory, like the University of Texas at Austin or Dallas, held advantages for Jewish emigrants like Wolfgang Rindler and

²⁸As is clear from his correspondence, Jordan had favored Jürgen Ehlers to become his successor [212] I owe the knowledge of this letter to Dr. A. Blum, Berlin.

²⁹Seifert eventually became professor at the Hochschule der Bundeswehr (now Helmut Schmidt University) in Hamburg like another doctoral student of Jordan, Henning Müller zum Hagen.

Alfred Schild (1921-1977), and for West-German relativists like those of the Hamburg group. They achieved a lot; e.g. in 1963, in order to make the University of Dallas known in the scientific world, the “Texas Symposium [later “Conference”] on Relativistic Astrophysics” was founded by Alfred Schild, Engelbert Schücking (1926-2015) and Ivor Robinson (1924-2014) [213] which celebrated its 50th anniversary in 2013 [214].

In the group around G. Ludwig in Berlin, a PhD thesis of 1962 by Karl Kraus (1938-1988) written under the guidance of Kurt Just investigated a Lorentz-invariant gravitational theory. In 1961 K. Just left for the University of Arizona in Tucson and the work on gravitation finally came to an end around 1963 when Ludwig took a position at the University of Marburg and Kraus went with him as his assistant. Other smaller groups developed at the Technische Hochschule Braunschweig, around Max Kohler and at the University of Freiburg/Brs. around Helmut Hönl (1903 -1981) and his assistant Konradin Westpfahl (1926-1994), at the time a lecturer. As their publications show, for both, Kohler and Hönl, at first gravitation formed a side issue compared with transport theory and diffraction optics [215], [216], [217]. Between 1951 and 1953, Kohler published four papers on general relativity and bi-metric theory. Hönl had a paper on Mach’s principle in 1953 and in 1955 a single paper on the gravitational field of rotating masses with A. W. Maue [218]. After his call to the university of Göttingen, Kohler continued to work in both fields while Hönl in Freiburg turned mainly to general relativity, studying, among other themes, with H. Dehnen the role of Mach’s principle, and with K. Westpfahl equations of motion of point particles. In 1970, H. Dehnen became the only one appointed as full professor in the field of relativistic gravitational physics in the Federal Republic (BRD) after Jordan and until today (University of Konstanz). Since the mid 1960s, Friedrich W. Hehl, Technische Universität Clausthal, introduced research on spin-angular momentum within theories of gravitation with torsion and, after his appointment at the university of Cologne in 1975, built up an active research group directed, among others, to Poincaré gauge theories of gravitation. In Würzburg, the theoretical physicist R. Ebert (1926-2013) guided a group working in relativistic astrophysics from which R. Breuer, W. Dietz and, through his habilitation, E. Hilf emerged.

The situation of gravitational research in BRD (and to lesser extent in GDR) reflected itself, more or less properly, at the meeting of the German

Physical Society from Oct. 4-9, 1965 in Frankfurt am Main (Jahrhunderthalle der Farbwerke Höchst AG). Included were a plenary talk “Neuere Entwicklungen in der Allgemeinen Relativitätstheorie” by J. Ehlers (Dallas), on Friday, Oct. 8, a topical session (“Fachsitzung B”) under the chairmanship of Pascual Jordan, and an additional meeting during which talks were presented which, in the program, were listed under the heading “Further contributions not to be presented orally”. The topical session contained two Fachberichte by G. Ludwig, Marburg and H. Hönl, Freiburg as well as 8 further short talks by people from Hamburg (3), Freiburg (3) and from GDR (Schmutzer, Treder). The five additional presentations came from Hamburg (3) and Freiburg (2) ([219], p. 61, 64-67). I imagine that the initiative started from P. Jordan who invited other groups to join. That only 2 representatives from GDR were there, the leaders of the 2 main groups in Potsdam and Jena, possibly was due to the very restrictive policy concerning traveling into countries outside the “iron curtain”. I visited the meeting and took along my adviser Prof. K. Westpfahl with the car lent from my parents.

In 1965, the 50th anniversary of the completion of General Relativity was celebrated in Berlin both in East and West, but now separately.³⁰ In East-Berlin, H.-J. Treder and the Academy - whose name in 1972 would be changed into Academy of Sciences of GDR - correspondingly organized a big international symposium [220].

Following intensive debates during the Frankfurt-meeting of the German Physical Society, a public dispute between the assertive J. Ehlers and E. Schücking on the one side, and H. Dehnen on the other, surfaced concerning both the physical interpretation of an exact solution of Einstein’s equations, and Mach’s Principle [221], [222]. As a consequence, the then co-editor of *Zeitschrift für Physik*, Nobel prize winner H. Jensen, decided to stop printing articles on general relativity.³¹ It is possible that this damaged Ehler’s image at universities in BRD, because his attempts to obtain a full professorship at a university seemingly failed. In 1971, through an initiative of the astrophysicist Ludwig Biermann (1907-1986), director at the Max-Planck-Institute for Physics and Astrophysics in Munich, Jürgen Ehlers was invited

³⁰The Berlin Wall finally separating both Germanies had been erected in August 1961.

³¹Interestingly, in the 1950s, S. Goudsmit then editor of *Physical Review* also intended to ban papers on general relativity from this journal. Cf. [223], p. 414. This reference has been taken from [224].

to join this institute as director of a permanent working group on gravitational theory. The importance of Biermann's initiative may be seen in that it brought astrophysicists and relativists into closer cooperation. At the same time, Ehlers was named honorary professor at Ludwig-Maximilian University. His group became the first permanent anchorage ground for gravitational research in West-Germany independent of university financing. Since fall 1979 until 1982, M. Trümper joined the group in Garching. Other members of the Hamburg group like B.G. Schmidt who had written his dissertation with P. Jordan and developed the concept of b-boundary of a manifold, or H. Friedrich, joined Ehlers on permanent positions.

While the establishment of Ehler's group definitely represented progress for the standing of the field of gravitation within the German physics community, it also aroused some jealousy among the small groups at the universities. This was due to the much better financial means provided by the Max-Planck-Society for the organization of meetings, invitation of guests from abroad, travel to conferences etc. Above all, the positions at Max-Planck-Institutes were full-time research positions with no teaching obligations.

At the joint meeting of the German and Austrian Physical Societies and the German Geophysical Society in Salzburg, 29. Sept. to 4. Oct. 1969, the "Festvortrag" was held by W. Thirring on "Gravitation". A topical meeting "Relativity theory and cosmology" took place under the joint chairmanship of Max Kohler, Göttingen, and Roman Sexl, Vienna. There were talks by N. (?) Bondi, (Neuilly-sur Seine) [Must really have been Hermann Bondi, cf. his "Gravitational bounce in general relativity", *Monthly Notices of the Royal Astronomical Society* 02/1969; 142], and F. Pirani, as well as 2 further talks from the Hamburg group (H.-J. Seifert, O. Störmer) and a talk by J. K. Lawrence from the theoretical physics institute of the University of Vienna. As an assistant of M. Kohler, I attended the meeting ([225], p. 683, 688-690).

Thus, until the 1970s, the situation in the Federal Republic of Germany was very much the same as the one before the war: around some single professors small groups were pursuing gravitational research. This was not exactly a stable situation; financial support came from universities and personal applications to the German Science Foundation. In 1973, during an international Symposium in Bonn, P. Jordan pointed out that "[..] the present state is such that [...] in the area of the Federal Republic the theory of General Relativity does not at all receive the deserved recognition and research

on it is not adequately continued” ([226], p. 2). As this symposium and a preceding one in 1971 shows, there was some general interest also among mathematical physicists.

In 1978, an international conference, the 9th Texas Symposium on Relativistic Astrophysics, was held in Munich under the auspices of the Max-Planck-Institute for Astrophysics [227]. On 2 March 1979, under the auspices of the German Physical Society, a Gedenkveranstaltung zum 100. Geburtstag von Albert Einstein, Max von Laue, Otto Hahn und Lise Meitner” was held in Berlin with J. A. Wheeler, Austin presenting a talk “Einstein und was er wollte” [228], [229].

In spite of all the celebrations, until the late 1970s only about 20 permanent positions for scientists doing research in general relativity were available in the Federal Republic of Germany. Among them, three full professorships (Freiburg, Konstanz, Würzburg) and three associate professorships (Göttingen, Köln, Bonn). We may add the position of J. Ehlers at the Max-Planck-Institute for Physics and Astrophysics in Munich and a professorship at the Bundeswehrhochschule in Hamburg [230].

3.2 German Democratic Republic (GDR)

3.2.1 The first decades until 1980

At its beginning, in the German Democratic Republic a very different situation obtained. The predominance of the “working class”, as forcefully set by the party in power, SED (Sozialistische Einheitspartei Deutschlands), resulted in some hostility against academic labor which until then was anchored in the middle class (bourgeois intelligentsia). But for an efficient economy, the old and many new university graduates were needed: An aspired goal of the late 60s was to educate until the 1990s the majority of the workforce at advanced technical colleges and universities ([231], p. 7). In GDR, two ministries were responsible for research and teaching, the “Hochschul”-, and “Wissenschaftsministerium”, at times rivaling each other.

In this context, the German Academy of Sciences in Berlin was given a leading role for research, particularly in the exact sciences, following the example of the Soviet Academy of Sciences. With Albert Einstein as one of its former prominent members, the party’s intention was to continue research on his theory. With the appointment of Achille Papapetrou, in 1952, to the

Research Institute for Mathematics of the German Academy of Science, a seed for research and teaching in general relativity was planted. Papapetrou, who due to his leftist political opinions had been dismissed from his professorship in Greece, came from a temporary position with Leon Rosenfeld in Manchester. He had been recommended by Einstein's former collaborator E. Freundlich³² who had emigrated to England and who had been consulted during the preparation of a solar-eclipse-expedition by the Berlin Academy. Freundlich did not want to become totally involved and suggested A. Papapetrou as a coworker. Papapetrou's position in Manchester ran out at about the same time [232]. In August 1951, he obtained a position in the Research Institute for Mathematics of the German Academy of Sciences in Berlin and in 1953 became head of a research group for mathematical physics [233]. In 1957, Papapetrou was promoted to professor at Humboldt University in Berlin. One of his first doctoral students was Hans-Jürgen Treder (1928-2006); he obtained his PhD in 1956, his habilitation in 1960 on shock waves and became a heavyweight in gravitational research within the Academy. He had been a member of the communist party in West-Berlin; his contacts with influential members of the State's party like Kurt Hager (1912-1998), member of the Central Committee responsible for all cultural affairs, and the well known physicist Prof. Robert Rompe (1905-1993)³³ made him politically unassailable. After the construction of the "Berlin Wall", Treder left West-Berlin to settle permanently in East-Berlin or, as it was then called by the GDR-authorities: "the Capital City of GDR". Another doctoral student of Papapetrou was Georg Dautcourt at the Institute for Pure Mathematics of the Academy [234] who at first could establish a research group but which in 1971 was dissolved after he had criticised Treder's research agenda. Eckhard Kreisel also belonged to Papapetrou's doctoral students but could not finish the work before Papapetrou left.

Papapetrou left GDR in 1961/62 for Paris. In the aftermath, H.-J. Treder became professor for theoretical physics at Humboldt University in Berlin and from 1963 to 1966 director at the Institute for Pure Mathematics of the Academy. As a consequence of the 3rd University- and Academy-Reform of 1968 in GDR [235], several astronomical observatories and astrophysical institutes became merged under the umbrella of the Academy. Since 1969,

³²He had changed his name to Finlay-Freundlich by putting his mother's name in front.

³³Treder is coauthor of 7 books with Rompe.

Treder was in charge of the newly launched “Central Institute for Astrophysics” (ZIAP). The “Central Institute” belonged to the research domain “Cosmic physics” of the Academy and was focused more on experimentation/observation. With his function, Treder obtained a seat in the steering committee of the Academy. He was very productive until his death; some of his hundredths of publications are listed in an obituary [236]. His research was directed toward unification of gravitation and electrodynamics, alternative gravitational theories (tetrad theory, curvature squared Lagrangians), shock waves in Einstein’s theory, and a mechanics without inertial mass. As Treder’s research topics kept aloof from the mainstream of international research in gravitation and mainly published in German, most of his papers and books had a very limited influence on international developments in general relativity.

Earlier, gravitational research had been followed also at other universities of GDR, e.g., in Greifswald and Leipzig by Dietmar Geißler, Hans-Georg Schöpf and Adolf Kühnel, respectively. Schöpf was transferred to mathematical physics in Dresden; Kühnel went into condensed matter physics. Also, in Leipzig around P. Günther in the mathematics department, interest on particular problems related to Einstein’s equations originated. His doctoral students R. Schimming, then professor in Greifswald and V. Wünsch (1941-2015), professor at the Pedagogical University Erfurt, and after retirement in the faculty of mathematics of the University in Jena, took up this work. In the 1970s and 1980s, we can speak of an institutionalization of research on relativity and gravitation in terms of a stable structure with two centers. That the two groups were not really cooperative but rather in competition is another story.³⁴ An idea envisaged with the 3rd University- and Academy-Reform was that research and teaching should be separated – with the institutes of the Academy responsible for research and the universities for teaching. The example of the University Jena shows that this idea could not be enforced in practice. At the beginning of the 1970s, the original demand to bind research in the natural sciences at the universities to industrial research became also relaxed. ([237], p. 147) Nevertheless, the Institutes of the Academy of Science of GDR had much better resources; e.g., in general twice as many positions than the universities [238].

³⁴The situation may be mirroring the relationship between Wissenschafts- and Hochschulministerium of GDR with the first one being closer to Treder.

After having obtained in 1955 his PhD with Hans Falkenhagen at the Wilhelm-Pieck-University Rostock, Ernst Schmutzer became his assistant and in 1956/57 gave the first courses on general relativity in Rostock after World War II. In 1957, he moved to the Friedrich-Schiller-University of Jena, obtained his habilitation there in 1958, and was appointed professor in 1960. With a couple of master-degree students, he managed, during the 1960s, to establish a group for research in general relativity and 5-dimensional gravity [239], [240]. His request to the ministry in Berlin, i.e., to approve a main focus “relativity and gravitation” in Jena, was accepted. Members of the faculty³⁵ working in general relativity and/or in astrophysics were Dr. Hans Stephani (1935-2003); Dr. Nicolaus Salié; Dr. Dietrich Kramer, Dr. Gernot Neugebauer³⁶; Dr. Eduard Herlt; Dr. Rainer Collier; Dr. K.-H. Lotze among others.³⁷ Important results were obtained, in particular with regard to exact solutions of Einstein’s field equations, by G. Neugebauer, H. Stephani, E. Herlt and D. Kramer, among others. E. Schmutzer and his colleagues, within the framework of the Relativity Seminar at the University of Jena, also organized international colloquia in Georgenthal, Thuringia, where scientists from both sides of the “Iron Curtain” could meet and discuss, e.g. the 14th Seminar, 15. - 21. Nov. 1982, or the 15th Seminar 26. 11. - 2. 12. 1984.³⁸ Before the end of the 1980s, Reinhard Meinel joined the group on general relativity in Jena .

3.2.2 The last decade before the end of GDR

In 1979, for the 100th anniversary of Einstein’s birthday, conferences were organized in both parts of Berlin. In West-Berlin the title of the conference was “Einstein Symposium” and its contributors were many of the leading relativists of the “West”, politically speaking [241]. Some of them like J. A. Wheeler gave a lecture both in East and West.

³⁵Mathematisch-Naturwissenschaftliche Fakultät; between 1968 and 1990 “Sektion Physik”.

³⁶In fact, Neugebauer was working with Gerhard Kluge on relativistic thermodynamics and not directly related to Schmutzer.

³⁷No distinction has been made between doctoral titles like Dr.rer.nat.habil. or Dr. sc.nat. granted in GDR during different periods. Also, differing positions, like lecturer or assistant professor are not shown.

³⁸Only a few persons from this group, belonging to the so-called travel-cadre (Reisekader) were permitted to travel into Western countries.

One year later, in 1980, the only large *international* conference in Germany under the auspices of the “International Society of Relativity and Gravitation”, GR 9, was organized by E. Schmutzer and his co-workers and colleagues in Jena in GDR, not by Treder’s group. According to those involved in Jena, it took quite some negotiations with the Party and the Ministry before GR 9 could be run in Jena.³⁹

Following the “Forschungs-Verordnung” of June 1986, the universities in GDR were again obliged to use a minimum of 50% of their research-potential for industrial research and development ([231], p. 11). This was due to the precarious financial situation in GDR. In 1982, Treder handed over the ZIAP to his successor, the astronomer Karl-Heinz Schmidt (1932-2005), due to health problems. He was appointed director of a newly founded Einstein-Laboratory for Theoretical Physics in Potsdam-Caputh⁴⁰ and remained in this position until 1992. Treder’s Institute included: Dr. Dierck-Ekkehard Liebscher, Dr. Eckhard Kreisel who likewise had written his thesis in 1965 under Treder’s tutoring⁴¹, Dr. Horst-Heino von Borzeszkowski who had received his PhD with Treder in 1973 and Dr. habil. Ulrich Bleyer. Dr. R. W. John from ZIAP, although associated with Treder, scientifically went his own way.

A philosopher of science, Dr. Renate Wahsner, for some time also belonged to the Einstein Laboratory. Further coworkers in general relativity were Dr. H. Fuchs, Dr. S. Gottlöber, Dr. U. Kasper, Dr. J. Mückel, Dr. V. Müller and Dr. habil. H.-J. Schmidt. Until 1986 when he left GDR, also Prof. Dr. Helmut Günther (1940-) had worked in both the Zentralinstitut für Astrophysik and the Einstein-Laboratory for Theoretical Physics⁴²

Thus around 1979, in GDR manpower in terms of salaried positions surpassed the one in FRG; this includes leading positions. In Treder’s group (Zentralinstitut für Astrophysik and Einstein-Laboratorium) one full professorship existed (H.-J. Treder, member of Academy of Science) plus two senior collaborators D.-E. Liebscher, E. Kreisel. At the University of Jena E. Schmutzer was full professor and group leader with two further senior

³⁹In 2016, GR 21 will be held in New York City.

⁴⁰With two sites at the observatory in Babelsberg and in the former summer house of Albert Einstein in Caputh.

⁴¹Both were titular professors.

⁴²In 1972, he had obtained his Dr. sc. nat.; he later published on disorder in lattice structure and on Lorentz-symmetry.

collaborators, D. Kramer, H. Stephani and another one in relativistic thermodynamics (G. Neugebauer). In FRG, the field contained only one full professorship (H. Dehnen, Konstanz) and three associate professors (H. Goenner, Göttingen; F. W. Hehl, Köln; K. Westpfahl, Freiburg).

3.3 Foundation of a subdivision within the German Physical Society in BRD and its impact.

A first sign toward formation of a “community” showed up in June 1971 during a “Colloquium on Relativistic Astrophysics” in the observatory “Hoher List” under the patronage of German Science Foundation (DFG). New astrophysical objects like quasars, pulsars and neutron stars had come into the center of interest. M. Reinhardt⁴³ of Bonn University gave a report of the 5th Texas Symposium on Relativistic Astrophysics at the University of Texas at Austin in Dec. 1970. As a consequence of the discussions, a request for the establishment of a priority program “Relativistic Astrophysics” to be funded by DFG was drafted. It became implemented, supervised by Erich Kirste (1927-2002) from DFG, and coordinated by J. Ehlers, Munich during the 5-year period of 1974-1979. Of the total of 71 funded projects, 57% (41) went to astrophysics while only 43% (30) were relevant to general relativity. Half of the support for these 30 research projects went to the two biggest groups in Hamburg (W. Kundt, B. G. Schmidt) and in Munich (J. Ehlers) – both offspring of Jordan’s seminar. It is true that in particular some scientists with a background in nuclear physics working for the understanding of neutron stars, like Peter Mittelstaedt (1929-2014), Cologne, and Konrad Bleuler (1912-1992) in Bonn, took also advantage of the priority program. Nevertheless, one of the intentions of this program, i.e., to awaken the interest of more universities toward establishing research groups or positions in (relativistic) gravitation turned out to be a failure [230].

The initiative for the foundation of a subdivision (“Fachverband”) “Gravitation and Relativity” within the German Physical Society (DPG) arose from informal discussions among J. Audretsch (Konstanz), H. Goenner (Göttingen) and F. W. Hehl (Köln). After H. Dehnen (Konstanz) had been convinced of the idea and had contacted J. Ehlers, a meeting on general relativity was

⁴³M. Reinhardt later became professor at the University of Bochum, but died young in 1985.

organized in September 1983 by J. Ehlers, B. G. Schmidt and M. Walker, supported by the Max-Planck-Institut for Physics in Munich. It was held at Castle Ringberg near Tegernsee ([242], p. 223). Now, the wish to organize gravitational research within the German Physical Society was communicated and backed by the participants. Further discussions took place on 22./23 June 1984 during a Köln-Göttingen-Colloquium in Cologne. The actual foundation of the Fachverband took place on October 3/4, 1984 in the conference center “Physikzentrum Bad Honnef”, in the presence of the then president of DPG, Prof. J. Treusch, after the DPG had become convinced that a sufficient number of “relativists” would become members. As H. Dehnen, at the time dean in Konstanz, did not run for office and F. Hehl was away in the USA, J. Ehlers became elected first president. He organized a first working meeting on “Gravitation and Relativity” in Bad Honnef from 8.-13. Dec. 1985 with a sizeable number of participants, also from Switzerland and Austria.⁴⁴ Further such meetings followed every two years, partly as WE-Heraeus-Seminars. The chairmanship of J. Ehlers who had been re-elected once, lasted until 1989, when Gerhard Schäfer, Munich, succeed him during the 3rd working meeting of the Fachausschuss [247].⁴⁵ After G. Schäfer, F. Hehl, Cologne, became the next chairman. Thus, also in the Federal Republic of Germany (BRD), a stable reference base for research on general relativity had come into being. Apart from the organization of its own meetings, the main activity of the Fachausschuss (later renamed Fachverband) within DPG consisted in taking part in the yearly meetings of the German Physical Society by supplementing plenary talks and subsections of the program. This was organized by the chairmen at the time. Relativists thus had a continuous platform for presenting their work. It should be noted that there is no corresponding subdivision for astrophysics within the DPG; this field finds its base in the German Astronomical Society.⁴⁶

⁴⁴At the University of Vienna, Roman U. Sexl (1939-1986) was professor for Cosmology and General Relativity since 1972. The joint work with his colleagues in Vienna, Peter Aichelburg, on the ultraboost of the Schwarzschild vacuum [243] and Helmuth Urbantke on cosmic particle creation [244] as well as his many books are well-known [245], [246]. Two further, more mathematically inclined, colleagues of the group must be presented, i.e., Robert Beig and Piotr T. Chrusciel. Unfortunately, the intended section concerning research on general relativity in Austria and Switzerland still waits to be written.

⁴⁵Gerhard Schäfer had been a student of H. Dehnen in 1973-1986 and post-doc with J. Ehlers in 1988-1992.

⁴⁶The title of this year’s (2016) 89th general assembly shows this clearly: “The many Facets of Astrophysics - Photons, Particles, and Spacetime.”

3.4 Situation after German re-unification 1990

After the German Democratic Republic, on October 3, 1990, joined the Federal Republic of Germany, on November 20, 1990, the Physical Society of the GDR also merged with the DPG. A restructuring of the scientific landscape of the former GDR was started, in particular of the Institutes of the Academy of Science. They were given the guarantee that operation would be financed until Dec 31. 1991. It was unclear what would happen to the Zentralinstitut für Astrophysik and, particularly, to the Einstein-Laboratory for Theoretical Physics, in both of which research on general relativity had been done. In all likelihood, the Einstein-Laboratory would not be continued despite the pleading of international supporters like Peter Bergmann of Syracuse: H.-J. Treder had become permanently ill, passed his zenith, and – in the eyes of West-German opinion leaders – was compromised by his closeness to the ruling party SED. In retrospect, it seems clear that, by this connection, he had been able to play an important role in securing financial support for research in gravitation.

A phaseout of Treder’s group in Potsdam followed, with some of its members like U. Kasper, H.-H. v. Borzeskowski and H.-J. Schmidt then receiving 2-year-contracts for pursuing research in gravitation under a program with the typically German name “Wissenschaftler-Integrationsprogramm” (integration program for scientists). WIP ran out at the end of 1996. Eventually, some of those working in the Zentralinstitut für Astrophysik, like H. Fuchs, S. Gottlöber, D.-E. Liebscher, J. Mückel and V. Müller, could join the Leibniz-Institut für Astrophysik in Potsdam. Dr. Bleyer became head of Urania in Berlin.⁴⁷ H.-J. Schmidt joined the mathematics department of the newly established University of Potsdam.⁴⁸

In contrast, gravitational research in Jena could adapt more softly to the new situation. E. Schmutzer’s co-workers with salaried positions could stay in the physics department of the university (Stephani, Kramer, Salié, Herlt, Collier). G. Neugebauer was invited by the president of the Max-Planck-Society to establish in Jena one of the 28 working groups supported by the Society for a duration of five years. The members of the group chosen by

⁴⁷Urania, founded in 1888, is a privately organized association the aim of which is to communicate the most recent scientific findings to the broad public.

⁴⁸From 1996 to 2005, he was editor of the scientific journal *General Relativity and Gravitation*, published since 1970 under the auspices of the International Society on General Relativity and Gravitation.

Neugebauer were R. Meinel and A. Kleinwächter, both of Jena, W. Kley, at the time in the United States, and Gerhard Schäfer from Ehler's group in Garching/Munich. In 1996, the group became absorbed by the physics department of the university.

A reorganization also took place in former West-Germany: In 1991, the Max-Planck-Institute (MPI) for Physics and Astrophysics was split up into three independent institutions, the MPI for Physics, the MPI for Astrophysics and the MPI for extraterrestrial Physics, originally established as a subdivision in 1963. The working group "Gravitational theory" under its director J. Ehlers continued in the MPI for Astrophysics until 1995.

Right after the German "re-unification", on February 8, 1991, Friedrich Hehl, Cologne and Hubert Goenner, Göttingen, formulated a Memorandum on the foundation of an International Einstein Center in Potsdam/Caputh.

"Quite certainly, no 'relativist' will be appointed to the full professorships mentioned above after retirement of the present incumbents. As seen from the international standard of competition in a fundamental branch of modern physics, for junior researchers this situation is, consequently, rather discouraging in terms of job openings etc. A closing down of the Einstein-Laboratory, without substitution, would appear irresponsible under such circumstances."

This memorandum was submitted to the secretary of the German Council of Science and Humanities (Wissenschaftsrat) on Feb. 1991 and later announced in the journal "Physikalische Blätter" related to the German Physical Society [248]

The original plan to establish a joint German-Israeli research institute won the approval of the famous Israeli theoretical physicist Yuval Ne'eman (1925-2006);⁴⁹ the intention was to approach the German-Israeli Foundation for Scientific Research (GIF) to take part in this initiative besides the German Federal Ministry for Science & Technology and the State of Brandenburg. It turned out, however that, due to its bylaws, GIF could not permanently support such an Einstein Center. Also, the State of Israel was short of money to be used for an eventual establishment of the necessary two Einstein Centers,

⁴⁹Y. Ne'eman co-discovered SU(3)-symmetry in particle physics. He was president of Tel Aviv University (1971-1975) and founder of the Israel Space Agency in 1983.

one in Jerusalem, the other in Germany.

Fully aware of this initiative and of its missing institutional background, in July 1991, the German Council of Science and Humanities suggested to the Max-Planck Society the establishment of a working group for the eventual foundation of an Albert-Einstein-Institute on a national basis. The working group was then formed with Jürgen Ehlers as its chairman. This way of proceeding was supported by the Fachverband Gravitation and Relativity through its chairman, G. Schäfer, and by the then president of DPG, Th. Mayer-Kuckuk (1927-2014). To the physics community, neither the members of this group nor its proceedings were communicated. It was not before the summer of 1993 that a “Memorandum on the founding of an Albert Einstein Institute für Gravitationsphysik” was issued and invitations for comments from the community during a “Symposium on Developments and Trends in Gravitational Physics” held on Sept. 20-21, 1993 in Munich sent around. Max-Planck Society had introduced a “Scientific Organization Committee” with J. Ehlers and the directors of two other Max-Planck-Institutes among further individual members. The memorandum emphasized:

“What is missing is an institute where researchers from Germany and abroad can collaborate for reasonable periods of time. An Einstein Institute could serve this purpose and thus stimulate also both research and teaching at universities. Universities cannot play this role: Positions are not available, high-level teaching requires a minimal number of people with small teaching obligations working in close contact with each other and with guests from abroad.”

Thus, similar to what had been formulated during the 3rd Hochschulreform of GDR in 1968, the intention was to clearly distribute tasks between low-level teaching at universities and research-oriented high-level teaching in close cooperation with Max-Planck-Institutes. The founding of the Institute also accepted the lack of positions for relativity research in Germany as unalterable. As it turned out, only those junior scientist already inside the Max-Planck-Society would obtain permanent positions in the new institute.

Eventually, the new Max-Planck Institute for Gravitational Physics (“Albert-Einstein Institute”) opened in Potsdam in 1995. J. Ehlers, Munich and B. Schutz, Cardiff became two of the directors of the newly founded

Institute for Gravitational Physics with three departments.⁵⁰ Unfortunately, by its construction the structure of the Albert-Einstein Institute showed that general relativity was considered as an appendix to either astrophysics and elementary particle physics, or to mathematics. With countless guests from abroad, the institute established a leading international role in research. Yet, the job-situation in Germany was not improved by the Albert Einstein Institute. The steady number of about 14 PhDs produced per decade in the field of general relativity, cosmology and relativistic astrophysics during the 1960s to the 1980s, remained uninfluenced by the new Max-Planck Institute for Gravitational Physics. In 2002, to the Albert-Einstein-Institute a fourth section on experimental gravitation (measurement of gravitational waves by interferometry) in Hannover (K. Danzmann) has been added – with recent great success.

4 Conclusion

At present, an institutionalization of research in relativistic gravitation has been achieved in Germany through a thriving topical section “Relativity and Gravitation” of the German Physical Society and a Max-Planck-Institute for Gravitational Physics. This topical section of DPG belongs to the smaller ones in comparison with elementary particle physics, physics of surfaces, semiconductor physics, nuclear physics, or quantum optics, etc.⁵¹ In this regard research on gravitation belonged to “Little Science” until experimental research for the observation of gravitational waves received big funds.⁵²

While an institutionalization of the field became achieved, the situation for young German relativists for entering into research in the field with a solid financing was not noticeably improved. Much of *research* in general relativity still is done in small groups at universities in Bremen, Erlangen-Nürnberg, Frankfurt, Hannover, Jena, Köln, and Oldenburg the continuation of which is not guaranteed. However, *teaching* of general relativity at universities no longer is an exception but has become a normality, although often as part of

⁵⁰Their third colleague H. Nicolai, Hamburg, joined them in 1997.

⁵¹A union of 6 sub-divisions of the DPG including the Fachverband “Relativity and Gravitation” with the name “Matter and Cosmos” has been established in 2012.

⁵²The concepts “Little Science” and “Big Science” go back to Derek de la Solla Price [249].

elementary particle physics or astrophysics, and by specialists in these fields. To some extent, Albert Einstein’s prestige has helped. What has not been achieved is a better standing of the field in the physics community in terms of more positions at universities. For the field of gravitation proper, there are even less positions now than at the beginning of this century. Thus, in 1999, it again was necessary to sound a warning statement about the decline of research in gravitation in Germany [250].

It has been claimed that a “renaissance” of general relativity has occurred in the 1960s to 1970s [251]. While it is true that the activity in research in general relativity increased in the 1960s, it is less clear whether one can speak of “renaissance”. The research-output before this period was always on a low but continuous level; important progress steadily having been made from 1916 to the 1990s.⁵³ It is also questionable whether the new field of “Relativistic Astrophysics” (since the 1950s) and the many papers on “Cosmology”, should be subsumed under general relativity. As we have seen, in Germany the “renaissance” of general relativity started immediately after world war II and continued slowly, but steadily.

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